AEPC RECOMMENDATIONS FOR BASIC TRAINING IN PAEDIATRIC AND CONGENITAL CARDIOLOGY 2020

Association for European of Paediatric and Congenital Cardiology

Educational Committee

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Table of Contents

1. Introduction
   1.1 Duration of training
   1.2 Objectives of training and trainee tasks
      1.2.1 Objectives
      1.2.2 Trainee tasks

2. General Training requirements
   2.1 Basic knowledge and skills
      2.1.1 Epidemiology, genetics, embryology, normal and abnormal anatomy of the cardiovascular system
      2.1.2 Physiology, pathophysiology and haemodynamics of congenital heart diseases
      2.1.3 Basic clinical and diagnostic examination
      2.1.4 Clinical knowledge of cardiovascular diseases
      2.1.5 Management of cardiovascular diseases

3. Specific Training Requirements
   3.1 Morphology, embryology, anatomy and epidemiology of cardiovascular disease
   3.2 Genetics and inherited cardiovascular disease
   3.3 Imaging Module
      3.3.1 Echocardiography
      3.3.2 Cardiovascular Computed Tomography and Cardiovascular Magnetic Resonance
      3.3.3 Nuclear cardiology
   3.4 Cardiac catheterisation and angiocardiography
      3.4.1 Haemodynamic investigations and angiocardiography
      3.4.2 Interventional catheterisation
   3.5. Diagnosis and treatment of cardiac rhythm disorders
      3.5.1 Clinical electrophysiology
      3.5.2 Invasive electrophysiological studies and catheter ablation
      3.5.3 Cardiac implantable electric devices (CIEDs)
      3.5.4 Inherited arrhythmia syndromes
      3.5.5 Arrhythmias in adults with congenital heart disease (ACHD)
   3.6 Intensive care
   3.7 Foetal Cardiology
3.8 Adult Congenital Heart Disease (ACHD)
3.9 Paediatric Pulmonary Hypertension
3.10 Heart Failure and transplantation
3.11 Levels of multidisciplinary family-centred psychosocial care
3.12 Sports Cardiology, physical activity and prevention
3.13 Congenital Cardiovascular Surgery

4. Certification of Completion of Training
   4.1 Training logbook
   4.2 Annual appraisal and assessment
   4.3 Final assessment

5. AEPC Examination

6. Logbook and additional information
   6.1 Logbook of procedures
   6.2 Procedures / activity

7. References
1. INTRODUCTION

The recommendations of the Association for European Paediatric and Congenital Cardiology (AEPC) for basic training in paediatric and congenital cardiology required to be recognized as a paediatric cardiologist by the AEPC are described below.

Those wishing to achieve more advanced training in particular areas of paediatric cardiology should consult the training recommendations of the different AEPC Working Groups available on the AEPC website (www.aepc.org) and the respective publications 1-6.

The development of training requirements is the responsibility of the Educational Committee and the AEPC Council in collaboration with the Working Groups of the AEPC.

Trainees should be exposed to all aspects of general paediatric and congenital cardiology from foetal life to adolescence and adulthood. Centres performing generalised and specialised work in paediatric and congenital cardiology should be committed to deliver postgraduate training.

At each training institute, trainers should be appointed to supervise and act as mentors to the trainees. AEPC will provide basic teaching courses to supplement the training process.

The recommendations outlined below should be regarded as the minimum requirements to become a paediatric and congenital cardiologist. Care of patients with congenital heart disease (CHD) and heart disease in general should be provided by paediatric congenital cardiologists and adult congenital cardiologists. Both specialties can originate from education as a paediatric cardiologist or adult cardiologists depending on the specific requirements for education of specialists and transition of patients in each individual European country. This document focusses on the education as a paediatric cardiologist based on the education in paediatrics. As CHD patients are treated from foetal life until adulthood depending on the respective agreement of transition to the adult congenital cardiologist, the speciality is named “paediatric and congenital cardiologist” throughout this document. The training recommendations to become an adult congenital cardiologists are stated separately by the European Society of Cardiology (ESC) 7, 8.

1.1 Duration of training

The entry criteria for training in paediatric and congenital cardiology are a minimum of 3 years training in general paediatrics (including at least 6 months in neonatal intensive care). The duration of training in paediatric and congenital cardiology is 3 years.
1.2 Objectives of training and trainee tasks

1.2.1 Objectives
The fundamental objectives of training are to provide the best quality of care for the patients and a compassionate attitude to the patients and their parents or guardians.
- Training programs in paediatric and congenital cardiology should provide an environment for acquiring the knowledge, skills, attitudes and competence and clinical judgement essential for the specialty.
- Programmes should have an appropriate balance between clinical services, training and academic endeavours.
- Programmes should encourage a commitment to continuous education, teaching, research, critical thinking and deep insight into the practical and theoretical problems of the speciality. Therefore, it is important that the trainee undertakes clinical or basic research aiming presentation and publication of the findings.
- The trainee should be educated in specialised departments skilled in all fields of CHD management and officially being accredited for this specialty.

1.2.2 Trainee tasks
To ensure a sufficient experience, the trainee should participate in an appropriate variety of patient management:

**Out-patients:** The trainee should be involved in the management of out-patients under supervision. These should include patients from neonates to adolescents with a variety of congenital and acquired cardiac diseases and adults with CHD.

**In-patients:** The trainee should be involved in the management of in-patients under supervision. These should include patients from neonates to adolescents with a variety of congenital and acquired cardiac diseases and adults with CHD.

**Intensive care:** The trainee should spend ample time in the intensive care unit and should become involved in the treatment of a variety of congenital and acquired cardiac diseases in patients of all age groups.

**Multidisciplinary meetings:** The trainee should regularly attend multidisciplinary meetings where management decisions are discussed.

**On-call commitment:** The trainee should participate in the on call schedules of the department with backup support provided by a paediatric or adult congenital cardiologist in order to achieve adequate experience in the management of emergencies.
2. GENERAL TRAINING REQUIREMENTS

The 3 years of training consist of different basic components of the specialty as mentioned under point 3 “Specific Training” (as morphology/embryology/epidemiology, genetics, imaging, foetal cardiology, haemodynamics and catheterisation, cardiac rhythm disorders and cardiac intensive care). The training can be completed in more than one institution. The institutions have to fulfil the training criteria for the particular area.

Participation in appropriate AEPC-recognized basic teaching courses is encouraged. For further details, see also the recommendations of the respective AEPC Working Groups.

2.1 Basic knowledge and skills

2.1.1 Epidemiology, genetics, embryology, normal and abnormal anatomy of the cardiovascular system

A basic understanding of these should be achieved during the first year by regular teaching sessions and by attending appropriate courses. Attendance to a course on anatomy in congenital heart disease shall be encouraged. For details, see the subsequent chapter under point 3: “Specific Training”.

2.1.2 Physiology, pathophysiology and haemodynamics of congenital heart diseases

Understanding of the principles of cardiovascular physiology and pathophysiology of the congenital lesions is essential. The knowledge should be applied theoretically and as well in the clinical setting. Most common lesions are listed in Table 1.

2.1.3 Basic clinical and diagnostic examination

History taking and clinical physical examination

The trainee has to acquire the capability and knowledge concerning taking a profound history focussing on cardiovascular disorders. To take the patients history, a relationship with the patient and/or the parents based on trust and empathy has to be established. The trainee is expected to focus on the clinical history relevant to the cardiovascular disorder which includes the family and social history as well as the present symptom orientated history and past history. It is important to recognize comorbidities and associated risk factors.

The findings taken from the clinical history should be complemented and objectively evaluated by performing a complete clinical examination. The clinical examination should include the examination of the heart, lungs and the vascular system. The arterial pulses should be evaluated and the heart rate and rhythm examined. The trainee should know how to measure the blood pressure and measurement limitations. The clinical signs of under-perfusion and ascites or oedema should be recognized by the
trainee. The clinical examination should lead to an accurate observational summary of the clinical status of the patient with the intention to decide on a diagnostic and therapeutic strategy.

**Electrocardiography (12-lead ECG)**

The trainee should obtain basic knowledge and experience concerning evaluation of the electric activity of the heart. This includes the interpretation and formal reporting of a normal and abnormal electrocardiogram, audited by a trainer. The focus is on electrocardiac rhythm disorders, hypertrophy and signs of conduction disorders.

**24h ECG and exercise testing**

The trainees should become familiar with the 24h ECG and exercise testing protocols and the cardiorespiratory exercise test as well as with ECG monitoring for a longer time period and implantation of an implantable loop recorder (ILR). In detail, tests’ indications, limitations and contraindications should be known. The trainee is supposed to perform and systematically interpret the different test results in the clinical context. Complications of the exercise test and their management should be known.

**Chest x-ray and the principle X-ray dose reduction**

The trainee should learn to interpret chest x-rays of the patients under the care of the department at the start of training. Trainees’ interpretation and / or reporting of chest x-rays should be supervised and audited by a paediatric and congenital cardiologist, or by a specialised radiologist. The trainee should be acquainted with the interpretation and the clinical use of chest x-rays by the end of the training.

The trainee should gain sound knowledge of radiation protection of patients and staff and the effects of radiation on human cells, tissues and the growing body according to the ALARA (as low as reasonably achievable) concept. This also applies to the use of radiation in all types of x-ray oriented imaging techniques: diagnostic and interventional cardiac catheterisation procedures and computerized tomographic (CT) scanning. The requirements for an exam on radioprotection are addressed by each individual countries’ regulations.

**2.1.4 Clinical knowledge of cardiovascular diseases**

Knowledge of the cardiovascular symptoms and signs as well as their interpretation is mandatory. The clinical work should be under the supervision and guidance of an experienced paediatric and congenital cardiologist and focus on the following issues:
The trainee acquires knowledge of the embryology, detailed anatomy, physiology, epidemiology and natural history of cardiac disorders.

The trainee is able to make an accurate anatomical and physiological diagnosis on the basis of clinical information and investigations.

The trainee can interpret clinical information and the results of non-invasive and invasive investigations to determine the optimal treatment strategy.

The trainee knows indications, contraindications and limitations for medical, surgical and interventional treatment.

The trainee shall acquire the ability of decision making regarding diagnostic tools, therapeutic management and outcome.

The trainee understands the importance of close collaboration with colleagues from other disciplines, as surgery, radiology, anaesthesia and intensive care.

The trainee appreciates the role of the nursing staff, social workers, psychologists and physiotherapists in the care of children and adults who need intensive investigation and surgery.

2.1.5 Management of cardiovascular diseases

The trainee should acquire knowledge of different types of medical, surgical and interventional treatments of cardiovascular diseases (see Table 1). This should include the indications, results and associated complications of the treatment as well as the short-term and late outcomes. Focus is expected on the following issues:

- The trainee acquires knowledge of the actions and side-effects of cardiovascular and non-cardiovascular drugs and their interactions with other pharmacological substances in different diseases and at different ages.

- The trainee focuses on the importance of a multi-disciplinary approach: paediatric and congenital cardiologists, interventionalists, radiologists and cardiac surgeons have to be involved in the decision-making process. The detailed pre-operative or pre-interventional assessment should be encouraged and other sub-specialities be involved, if needed.

Basic, underlying principles of training are summarized in Table 2 (adapted from 3).

3. SPECIFIC TRAINING REQUIREMENTS

The special topics and issues in paediatric and congenital cardiology are addressed by the respective working groups of the AEPC. In accordance, the specific training requirements concerning
knowledge, skills and attitude are mentioned in detail per topic.

3.1 Morphology, embryology, anatomy and epidemiology of cardiovascular disease

The trainee is expected to gain profound insight in cardiovascular morphology and pathology. Participation of an AEPC-acknowledged course on cardiovascular morphology and pathology is strongly recommended for all trainees. Upon completion of the course the trainee is expected to have the following knowledge:

Knowledge:

- Principles of cardiovascular development, including the genetic factors and influence of embryonic/foetal haemodynamics.
- Anatomy of the normal heart including its topographical relationships in various periods of life.
- Principles of the sequential segmental analysis of congenitally malformed heart.
- Morphology of the cardiac conduction system.
- Morphological features of:
  - septal defects
  - anomalies of the outflow tract
  - anomalies of the right heart
  - anomalies of the left heart
  - anomalies of the systemic and pulmonary veins
  - anomalies of the aorta and connected arteries
  - anatomy of functionally univentricular hearts
  - morphology of lateralization defects’
  - morphological features of clinically significant coronary abnormalities
- Up-to-date terminology of congenital cardiac defects as recommended by the AEPC Coding Committee and current revisions of the International Classification of Diseases (ICD).
- Histopathological characteristics and staging of pulmonary hypertension.
- Morphological features of CHD in the adult population (including natural remodelling, post-surgical remodelling and other morphological topics relevant for this population).
Skills:
- Initiate the adequate management of the patient upon morphological and pathophysiological diagnosis.
- Interpret the results of the various imaging techniques (echocardiography, CT scan, MRI, angiography) according to the knowledge acquired in cardiac morphology.

Attitude:
- Coordination of patient management with involvement of the potential sub-specialties (geneticists, surgeons).

3.2 Genetics and inherited cardiovascular disease
The trainee should acquire knowledge and experience in the basis of genetics and on diagnosis and treatment of inherited diseases associated with cardiovascular disorders.

Knowledge:
- Principles of Mendelian monogenic human diseases being autosomal dominant, autosomal recessive and X-linked:
  - Mitochondrial patterns of inheritance
  - Polygenic cardiovascular diseases
  - Genes, genome, chromosomes
  - Methods: Sanger sequencing, Next-Generation Sequencing, Fluorescence in situ hybridization (FISH), Comparative Genomic Hybridization (CGH)
  - Relevance of polymorphisms and mutations
- Diagnosis and clinical presentation of most frequent syndromes:
  - Trisomy 21, 13, 18 and X0 (Turner)
  - 22q11 microdeletion syndrome
  - 7q11 microdeletion syndrome (Williams-Beuren) and elastin gene mutations
  - Noonan syndrome and RASopathies
  - CHARGE syndrome
  - ALAGILLE Syndrome
  - HOLT-ORAM syndrome
  - CHAR syndrome and other syndromes
• Diagnosis, clinical presentation and treatment of cardiomyopathies:
  - as hypertrophic -, congestive -, dilated -, restrictive and non-compaction cardiomyopathy
  - Mitochondrial diseases and Barth syndrome
  - Sarcomeric cardiomyopathies
  - Storage diseases and other inborn errors of metabolism
  - Neuromuscular disorders

• Diagnosis, clinical presentation and treatment of familial arrhythmias:
  - Long and short QT syndrome
  - Brugada syndrome
  - CPVT (Catecholaminergic polymorphic ventricular tachycardia)
  - Right ventricular arrhythmogenic dysplasia

• Diagnosis, clinical presentation and treatment of aortopathy syndromes:
  - Marfan syndrome
  - Loeys-Dietz syndrome
  - Ehlers-Danlos Syndrome, Thoracic Aortic Aneurysm and Dissection (TAAD) syndrome
  - Arterial tortuosity syndrome

Skills:
• Evaluate the family history and make a pedigree including the ability of interpretation (problems with pedigree interpretation as incomplete penetrance, variable expressivity and age-related patterns of expressivity).
• Patient counselling (including prenatal) in collaboration with the geneticist after genetic testing and management of the uncertainties associated with genetic testing.

Attitude:
• Ability to communicate sensitively regarding to genetic family disorders.
• Recognition of importance of a multidisciplinary team including the geneticists.

3.3 Imaging Module
The trainee should gain knowledge about the choice and frequency of imaging modality according to the lesion specific patient characteristics as well as the strengths and weaknesses of each imaging modality.
3.3.1 Echocardiography

The trainee should become familiar with the cardiac anatomy and physiology of congenital and acquired heart diseases using echocardiography following the sequential segmental analysis.

Knowledge:

- Physics of ultrasound imaging.
- Practical use of ultrasound equipment.
- Patient preparation.
- Indications for transthoracic and transoesophageal echocardiography in patients with congenital and acquired heart disease.
- Indications for foetal echocardiography.
- Echocardiography techniques (2D- and 3D-imaging, Doppler imaging, M-mode, contrast echocardiography, speckle-tracking echocardiography, stress echocardiography).
- Standard echocardiographic views.
- Quantification methods.
- Monitoring of interventional and surgical procedures using transoesophageal echocardiography.
- Limitations of echocardiographic techniques.
- Major echocardiographic developments.

Skills:

The ability to:

- independently perform, interpret and report transthoracic echocardiographic studies in patients with all forms of congenital and acquired heart diseases, both pre- and post-operatively.
- quantify cardiac structures including measurements of cardiovascular structures, ventricular size and function.
- perform basic transoesophageal studies.
- interpret fetal echocardiography studies.
Attitudes

- Interactive co-operation with paramedical staff, sonographers, referring colleagues and cardiac surgeons.
- Be able to recognize the advantages and disadvantages of echocardiography in various clinical situations and in relation to other imaging modalities.
- Be able to discuss echocardiography findings within a multidisciplinary team.
- Be able to decide for therapeutic medical, interventional and surgical treatment in the acute and chronic management of CHD from foetal to adult age.

3.3.2 Cardiovascular Computed Tomography and Cardiovascular Magnetic Resonance Imaging

The trainee should become familiar with cross-sectional cardiovascular imaging methods, their diagnostic potential and limitations including both, computed tomography (CT) and cardiovascular magnetic resonance imaging (CMR) 11.

Knowledge:

- Basic knowledge of CT Physics.
- Basic knowledge of CMR Physics.
- Basic knowledge of CMR pulse sequences and CMR methodologies.
- Basic knowledge of CT techniques.
- CMR: safety and patient preparation.
- CT: radiation exposure and protection, patient preparation.
- Indications for CT in patients with congenital and acquired heart disease.
- Indications for CMR in patients with congenital and acquired heart disease.
- Indications and complications of CT contrast agents.
- Indications and complications of CMR contrast agents.
- Limitations of CT and CMR.

Skills:

The ability to:

- select appropriate indications and avoid contraindications for CT and CMR scans.
- display and interpret CT and CMR images in the clinical context.
Attitudes:
- Be able to recognize the advantages and disadvantages of CT and CMR in various clinical situations and in relation to other imaging modalities.
- Be able to discuss CMR / CT findings within a multidisciplinary team.
- Interactive co-operation with paramedical staff, CMR / CT technicians, radiologists, referring colleagues, physicists and cardiac surgeons.

3.3.3 Nuclear cardiology
The trainee should become familiar with nuclear cardiology methods, their diagnostic potentials and limitations.

Knowledge:
- Basic principles and techniques of radionuclide imaging (SPECT, PET, lung ventilation/perfusion studies, PET-CT, SPECT-CT).
- Radiation exposure and safety.
- Indications for radionuclide imaging in patients with congenital and acquired heart disease.
- Limitations of radionuclide imaging.

Skills:
- The ability to interpret the results of radionuclide imaging.

Attitudes:
- Interactive co-operation with paramedical staff, nuclear medicine physicians, referring colleagues and physicists.
- Be able to recognize the advantages and disadvantages of radionuclide imaging techniques in various clinical situations and in relation to other imaging modalities.
- Be able to discuss radionuclide findings within a multidisciplinary team.

3.4 Cardiac catheterisation and angiocardiography

3.4.1 Haemodynamic investigations and angiocardiography
The techniques of cardiac catheterisation and angiocardiography will be encountered throughout the period of training.
The trainee should learn the technique of cardiac catheterisation and angiocardiography and also become proficient in haemodynamic calculations. The trainee should learn good practices in the catheterisation laboratory and concerning the method of angiocardiography meaning its benefits, limitations and the associated risks. The trainee should be able to perform diagnostic catheterisations independently by the end of the training period. However, these expectations will be governed by the regulations in individual countries (see recommendations of AEPC Interventional Working Group) 1.

3.4.2 Interventional catheterisation
The trainees should be involved in common diagnostic and interventional procedures as well as in emergency procedures. The goal is to provide basic knowledge of haemodynamics, angiography, radiation safety, indications, risks and benefits of interventional procedures in children and adult congenital patients 1.

Knowledge:
- Basic equipment for diagnostic and interventional procedures.
- Basic techniques of interventional procedures in paediatric and adult CHD.
- Views of cardiovascular angiography and peri-procedural imaging.
- Indications and complications of contrast agents.
- Indications and complications of drugs used for invasive procedures (heparin, isoproterenol, adenosine etc.).
- Indications, limitations of diagnostic and interventional procedures.
- Advantages and disadvantages of medical versus interventional and surgical management.
- Potential complications of diagnostic and interventional techniques with appropriate management strategies, including post-procedural and follow-up complications.
- Vascular access techniques and potential complications with appropriate management strategies.

Skills:
- Pre-procedural evaluation and care.
- Interpretation of haemodynamics and oximetry including calculation of blood flow, shunts, and resistances.
- Interpretation of angiographic images.
- Reporting of catheter data.
• Interpretation of catheter data, relationships with non-invasive evaluation and indication to interventions / surgery.
• Integrate transoesophageal and intracardiac echocardiography monitoring during interventional procedures.
• Management of post-procedural care.

Attitudes:
• Appreciate the anxiety and concerns of patients and relatives undergoing interventional procedures.
• Be able to discuss the advantages and disadvantages of different devices used in different clinical situations with patients.
• Appreciate the importance of radiation protection.
• Appropriate self-confidence and recognition of limitations.
• The importance of co-operation with cardiac surgeons.

3.5. Diagnosis and treatment of cardiac rhythm disorders

3.5.1 Clinical electrophysiology
The trainee should acquire knowledge concerning clinical symptoms, diagnosis and management of common paediatric arrhythmias. Evaluation of arrhythmia symptoms and skills in ECG differential diagnosis of common supraventricular tachycardias are essential. The trainee should acquire expertise in the acute pharmacological management of children with arrhythmias.

Knowledge:
• Understanding the mechanisms of tachycardias (re-entry, automatic, triggered).
• Types, recognition and differential diagnosis of supraventricular tachycardias.
• Paediatric dosages and side effects of drugs used for management of common supraventricular tachycardias.
• Aetiology and prognosis of paediatric ventricular arrhythmias and recognition of the common benign forms.
• Recognition, diagnosis and management of postoperative arrhythmias in the ICU.
• Aetiology, evaluation, therapy and prognosis of atrioventricular conduction block.
• Basic knowledge on diagnosis and treatment of foetal arrhythmias.
• Confirm the suspicion of cardiac syncope.
• Scientific background, theoretical limitations and cost effectivity of general ECG screening.
• The role of sport activity in preservation of health and its role in provocation of sudden cardiac death.

Skills:
• Competence in interpretation of standard ECG, ambulatory (Holter) ECG, exercise ECG and event based monitoring.
• Acute pharmacological management of children with arrhythmia.
• External cardioversion and defibrillation.

Attitudes:
• Awareness and appreciation of the psychological impact in patients undergoing pharmacological and invasive anti-arrhythmic therapy.
• Collaboration with electrophysiologists and heart failure specialists for patients with implanted devices.

3.5.2 Invasive electrophysiological studies and catheter ablation
The trainee should be involved in common diagnostic and ablation procedures. The focus is to provide basic knowledge of electrophysiological studies, indications, risks and benefits of invasive electrophysiology in children and adult CHD patients.

Knowledge:
• The trainee should know the indications for an invasive electrophysiological study and a catheter ablation in paediatric and congenital heart disease patients.
• Understanding the common arrhythmia mechanisms.
• The importance of radiation safety in terms of understanding deterministic and stochastic effects of fluoroscopy and the ALARA principle.

Skills:
• Ability to interpret the electrocardiogram tracings of a basic electrophysiological study.
Attitudes:
- Understanding the psychological impact of invasive arrhythmia treatment on young patients.

3.5.3 Cardiac implantable electrical devices (CIEDs)
The trainee should acquire basic knowledge on CIED therapy in children and in adults with CHD. They should know the indications and techniques for pacemaker, implantable cardiac defibrillator (ICD) and implantable loop recorder (ILR) implantation and basics of CIED programming.

Knowledge:
- Understanding indications and implantation techniques for CIEDs.
- Basic pacemaker/ICD programming – sensitivity, voltage, mode, rate, AV delay.
- Recognition of the paced ECG.

Skills:
- Ability to interrogate a CIED and program the basic pacing parameters.
- Recognition of infectious complications after CIED implantation.
- Recognizing the presence of pacemaker malfunction on ECG.

Attitudes:
- Understanding the psychological impact of CIED therapy on young patients.
- Aim a close collaboration with electrophysiologists in CIED related problems.

3.5.4 Inherited arrhythmia syndromes
Genetic testing and genetic counselling have evolved as an essential part of the diagnosis and management of inherited cardiac conditions. While genetic testing is clinically available for many of these conditions, it may not only identify clearly pathogenic causal variations in disease susceptibility genes but also genetic variants of uncertain clinical significance that may be difficult to interpret by the consulting physician. Genetic counselling should be delivered in cooperation with a specialized cardiac geneticist.

Knowledge:
- Understanding the conditions giving rise to channelopathies and cardiomyopathies.
- The role of genetic testing in suspected inheritable arrhythmia syndromes.
- Prognosis and management of the common inheritable arrhythmia syndromes.
Skills:
- Recognizing the common ECG signs of specific arrhythmia syndromes.
- Ability to plan and execute diagnostic genetic cascade screening in the family of an index patient.

Attitudes:
- Understanding the psychological impact of inherited arrhythmia syndromes on young patients and their families.
- Readiness for close collaboration with geneticists and electrophysiologists in diagnostics and management of patients with inherited arrhythmia syndromes.

3.5.5 Arrhythmias in adults with congenital heart disease (ACHD)
Arrhythmias are an important cause for morbidity and mortality in adult patients with CHD. The population of ACHD patients is increasing and with age there is an increasing burden of arrhythmias which are often complex. The trainee should understand how the modified postoperative intracardiac anatomy causes arrhythmia substrates in in various congenital heart defects.

Knowledge:
- The effects of cardiac surgery in producing arrhythmia substrates.
- The specific congenital defects associated with arrhythmias.
- The risk of sudden death in different conditions.
- Diagnosis and acute management of ACHD patients presenting with arrhythmias.
- Understanding the challenges in ECG diagnosis of arrhythmias in postoperative CHD.

Skills:
- Recognizing intraatrial re-entry tachycardia in the ECG.
- Ability to plan and execute acute management of arrhythmias in ACHD patients.
- Recognizing underlying residual hemodynamic lesions predisposing for arrhythmias.

Attitudes:
- Close cooperation with electrophysiologists, interventionalists and ACHD physicians in management of patients with arrhythmias.
3.6 Intensive care

The trainee should acquire experience in the daily activity of a paediatric cardiac intensive care unit including invasive techniques applied in daily patient care. It is also recommended to spend ample time in the cardiac operating theatre in order to learn the basics of cardiopulmonary bypass and to be aware of the different surgical techniques.²

Knowledge:

- Neonatal circulation, transition to extra-uterine circulation and its impact on clinical management of critically-ill neonates with cardiac disease.
- Basics of intensive care management of most common congenital and acquired heart diseases from neonates to adults in the pre- and post-operative as well as post-interventional setting.
- Principles of invasive and non-invasive cardiac monitoring (non-invasive blood pressure, EKG, oximetry, capnography, arterial lines, venous central lines, intra-cardiac lines (including right atrial, left atrial, pulmonary artery lines), Swan-Ganz catheter, emerging technologies).
- Evaluation and treatment of common neonatal cardio-circulatory disturbances in the absence of cardiac defects (i.e. persistent ductus arteriosus of the premature newborn, increased pulmonary vascular resistances secondary to persistent fetal circulation pattern).
- Evaluation and treatment of common cardio-circulatory disturbances in infants and adolescents in the absence of cardiac defects (i.e. cardiac dysfunction in septic shock, trauma, metabolic diseases).
- Currently used scores of severity in the ICU / heart surgery arena (i.e., STAT, RACHS, Aristotle, PRISM).
- Basics on pharmacokinetics and use of cardiovascular drugs (i.e. dopamine, dobutamine, isoprenaline, adrenaline, noradrenaline, levosimendan, phenylephrine, calcium chloride, vasopressine, sodium nitroprusside, nitroglycerine, nicardipine, hydralazine, phentolamine, phenoxybenzamine, beta-blockers and anti-arrhythmic drugs), including the management of their side-effects and interactions.
- Use of Prostaglandins E1, anti-coagulants, diuretics and the management of their side-effects and interactions.
- Deep understanding of physiology: focusing in cardiovascular physiology, principles of mechanical ventilation and cardiopulmonary interactions.
- Basic notions of cardiac anaesthesia.
• Basic notions of cardio-pulmonary-bypass (CPB), normo- vs. hypothermia, deep hypothermia circulatory arrest (DHCA).
• Basic notions on assessment and management of sedation, anxiolysis and pain.
• Basic notions on mechanical ventilation.
• Basic notions on nursing care and algorithms.
• Basic notions on nutrition of the critically-ill cardiac patient.
• Basic notions of cardiac and non-cardiac complications of cardiac surgery (renal, neurological, respiratory, haematological, gastrointestinal, infectious).
• Development of a philosophy of care and promotion of multidisciplinary team work.
• Acquisition of Pediatric Advanced Life Support (PALS), Advanced Cardiovascular Life Support (ACLS) and Basic Life Support (BLS) accreditation, including cognitive and skills evaluation.

Skills:
The ability to:
• perform PALS and ACLS and manage the patient in the post-resuscitation period.
• develop a structured approach to identify, manage and stabilize the patient with haemodynamic instability.
• use emergency monitoring equipment and to timely identify cardiovascular abnormalities requiring urgent intervention.
• use non-invasive tools like echocardiography and Doppler to manage critical ill patients.
• participate in the decisions to admit, discharge or transfer patients from the ICU.
• give cardiovascular system support:
  - perform arterial and central venous catheterisation.
  - measure and interpret haemodynamic variables.
  - use echocardiography appropriately in the acute and intensive care patient, including emergency and peri-resuscitation echocardiography as an independent operator.
  - perform pericardiocentesis.
  - treat and manage basic and complex arrhythmias in the acute care patient.
  - select and use fluids, inotropic, vasoactive, and anti-arrhythmic drugs.
  - use of external pacemakers (external pads, epicardial leads, trans-thoracic pacing).
• give respiratory system support:
  - identify the early signs of acute airway insufficiency and acute respiratory failure.
  - perform emergency tracheal intubation.
- obtain and interpret data from blood gas samples (arterial, central and mixed venous).

- comply with local infection control measures and appropriately manage antimicrobial drug therapy.

- correct fluid, electrolyte, metabolic and glucose disorders.

- assess neurological function (e.g. Glasgow Coma Scale).

**Attitudes:**

- Communicate, collaborate and team-work with the health care team (ICU nurses, ICU cardiologists, intensivists and other staff).

### 3.7 Foetal Cardiology

The trainee should become familiar with the present knowledge concerning foetal cardiology. The basic training level is recommended for all paediatric cardiology trainees. A close cooperation between the obstetrician or foeto-maternal specialist and foetal cardiologist is crucial for optimal perinatal management. The trainee should be familiar with the screening scan in low risk pregnancies at around 18-22 weeks of gestation as well as with the first trimester screening using the recognition of the increased nuchal translucency, abnormal ductus venosus flow and tricuspid regurgitation in the evaluation of an increased risk of congenital heart defects. The performance of an early anomaly scan in high-risk pregnancies is gaining importance. The trainee should be involved together with the obstetrician or foeto-maternal specialist to distinguish between the normal and abnormal cardiac status and establishing the primary diagnosis. Together with the specialist in foetal cardiology, the trainee should be involved in making the final diagnosis and counselling of the parents. The paediatric cardiologist should be able to interpret a foetal cardiac exam performed by a sonographer / other person and interpret the report, as well as have an understanding of the adequate care that the baby will require after birth. It is not necessary to perform the foetal echocardiogram by himself / herself.

**Knowledge:**

- Physiology of the foetal cardiovascular system:
  - foetal circulation: importance of the essential shunts: foramen ovale, ductus venosus, ductus arteriosus.

- Foetal pathophysiology and cardiac function and how this differs from the postnatal physiology.
• Congenital heart defects dependent on one or more of the prenatal essential shunts and the postnatal management required.

• Transitional circulation in healthy foetuses and those with cardiovascular problems.

• Prenatal evolution of cardiac defects:
  - indications for prenatal cardiac interventions.

• Congenital heart defects and genetic problems:
  - indications to perform genetic testing.
  - current available genetic tests and their interpretation in co-operation with geneticists.

• Foetal arrhythmia:
  - diagnosis of foetal tachycardia, bradycardia and inappropriate heart rates in the foetus (recognition of abnormal M-mode and Doppler recordings).
  - indications of referral of a foetus with an arrhythmia to a foetal cardiologist for further diagnosis and management.
  - indications and start of adequate prenatal treatment of a foetus with arrhythmia avoiding premature delivery.

• Foetal cardiac failure and cardiomyopathies:
  - differences between prenatal and postnatal causes.
  - application of the Cardiovascular Profile Score (CVPS) or similar scores to evaluate the foetal cardiovascular condition.
  - treatment options.

• Functional changes in the foetal cardiovascular system:
  - tricuspid regurgitation.
  - disproportion between right and left side of the heart.
  - regurgitation of the other cardiac valves (mitral, aortic and pulmonary).
  - prenatal closure or restriction of the ductus arteriosus and / or foramen ovale
    - aetiology and consequences for the neonatal condition
    - perinatal management and treatment options.

• Foetal cardiovascular abnormalities due to maternal pathology (as diabetes, lupus, antiepileptic medications).

• Indications for foetal cardiac echocardiography and Doppler.

• Limitations of imaging, especially in the first trimester of pregnancies.

• Legal regulations concerning termination the pregnancy in the specific country.
**Skills:**

The ability to:

- interpret and report a foetal cardiac exam performed by a sonographer or other person in order to detect cardiovascular problems in the foetus.
- detect warning signs when evaluating a foetal echocardiogram as size of the heart, foetal heart rhythm (abnormal 4chamber, outflow tracts, mediastinal view), abnormal Doppler and foetal hydrops.
- explain the parents a (preliminary) diagnosis of the foetal cardiac problem and know when to refer them to the foetal cardiologist consultant.
- discuss with parents the possible prenatal treatment options (like transplacental treatment for arrhythmia).
- discuss prenatal cardiac interventions when needed – together with the foetal cardiologist consultant.
- predict the possible outcome (early and late prognosis) and potential progression of the lesion during gestation.
- including lethal anomalies, together with the other partners of the perinatal team.
- discuss the perinatal period and postnatal management including early and late outcomes if the final diagnosis is established.

**Attitudes:**

- Ability to communicate sensitively and with compassion.
- Ability to break bad news.
- Awareness of the value of the prenatal counselling and documentation for a good continuation of postnatal care.
- Communicate, collaborate and team-work with the health care team (obstetricians, foeto-maternal specialists, geneticists, neonatologists, surgeons and other staff).

**3.8 Adult Congenital Heart Disease (ACHD)**

The remarkable improvement in survival of surgically and interventionally treated patients with CHD has led to an increasing number of adult congenital heart disease (ACHD) patients (former Grown-Up Congenital Heart Disease – GUCH).

For the trainee in general paediatric and congenital cardiology it is necessary to know about the basic
principles of CHD and the long-term outcome of the different lesions. Cooperation with other medical specialists (more or less the entire spectrum of adult medicine) will be utmost important 7.

Knowledge:

- The natural history of CHD, of surgical and interventional treatment (palliative and repair) and post-interventional course (residua and sequelae, long-term outcome, long-term complications).
- The optimal timing and indications for interventions (surgical and catheter) in unrepaired and repaired lesions.
- The role of non-invasive imaging techniques.
- The role of haemodynamics and when to derive them invasively. Specificities of interventional therapy in ACHD (balloon valvotomy, valve implantation, closure of shunt lesions, balloon dilatation and stenting of obstructive arterial and venous obstructions, occlusion of vessels).
- Surgical treatment strategies in ACHD (palliative, reparative, corrective, transplantation) and perioperative management.
- The basics about psychosocial aspects, typical cardiovascular risk assessment and influence of lifestyle – as physical activity, sports, contraception.
- Risk assessment of pregnancy in ACHD and management during pregnancy, labour, delivery and postpartum.
- The basics of clinical genetics for counselling.
- The need for vocational counselling and the obstacles encountered by obtaining insurances and driving license.
- The anatomical and functional complexity grade and their impact on patient management.
- Sufficient knowledge about transfer and transition from paediatric to adult congenital heart disease service.
- Sufficient knowledge about advanced care planning in ACHD: transitioning from repair to palliation and end-of-life care 14.
- Acquired cardiovascular disease (atherosclerosis, degenerative valvular heart disease, systemic hypertension etc.) and its prevention, diagnosis and treatment.
- Accompanying internal disease (pulmonary, renal, hepatic etc.).
- Risk assessment of non-cardiac surgery in ACHD and perioperative management.
Skills:

- Physical examination of ACHD (specific presentation of CHD during adult life).
- Interpretation of the diagnostic procedures in ACHD.
- ECG, exercise ECG, cardiopulmonary exercise testing and 24h Holter ECG or longer time monitoring in ACHD.
- Imaging techniques in the pre- and postoperative morphologic and functional assessment of ACHD (echocardiography, magnetic resonance imaging, multi-slice computed tomography, nuclear imaging) and their advantages in multimodality imaging.
- Interpretation of hemodynamic and angiographic findings from cardiac catheterization in adult ACHD.
- Diagnosis and treatment of heart failure in ACHD (taking into account the difference between CHD and acquired heart disease).
- Correct diagnosis and adequate treatment of pulmonary hypertension in ACHD.
- Diagnosis, drug treatment and interventional treatment of arrhythmias in ACHD (pathophysiology, non-invasive diagnosis, invasive diagnosis, drug therapy, electrical and interventional therapy (cardioversion, transitory stimulation, pacemakers, resynchronization therapy, ICDs, catheter ablation)).

Attitudes:

- Ability to communicate sensitively and with compassion.
- Ability to shift communication more and more from parents to the patient and later to patients’ direct familial environment.
- Ability to break bad news.
- Communicate, collaborate and teamwork with the health care team (cardiologists and their sub-specialties, radiologists, cardiac surgeons, obstetricians, geneticist and other staff).

3.9 Paediatric Pulmonary Hypertension

Pulmonary hypertension (PH) is a frequently occurring complication in congenital heart disease. Furthermore, patients with PH will often be referred to cardiologists or pulmonologists for assessment. It is therefore important that all paediatric cardiology training programs cover the basic training requirements that is recommended for all paediatric cardiology trainees 9,10.
The basic training requirements consist of the ability to diagnose PH in patients presenting with symptoms or in asymptomatic patients from high risk populations.\(^4\)

**Knowledge:**

- Recognition of the signs and symptoms of PH in children, ability to make a differential diagnosis and initiate treatment.
- Understand the pathophysiology and aetiologies, and subgroups of PH.
- Familiarity with a variety of diagnostic tools to confirm the aetiology of PH such as non-invasive imaging (echocardiogram and CMR), radiology, blood work, lung function test etc.
- Evaluation and interpretation of diagnostic cardiac catheterisation to confirm the diagnosis of PH, categorize the sub-type and quantify the severity.
- Recognition and quantification of elevated pulmonary vascular resistance in patients with CHD.
- Understanding the principles of medical management of PH (acute, chronic and decompensated).
- Familiarity with, diuretics, anticoagulation and commonly used pulmonary vasodilators, and age dependent variations in dosing.
- Understanding of the role of additional therapies in the PH management, including interventional such as creation of an inter-atrial communication.
- Indications and contraindications for repair of CHD in presence of elevated pulmonary vascular resistance.

**Skills:**

The ability to:

- take a proper history and examination for presence and aetiology of PH.
- perform an initial evaluation of the child with PH in the outpatient setting and identify likely contributory factors.
- perform an echocardiographic assessment of PH including diagnosis, physiology, shunts, presence of important CHD, assessment of afterload and ventricular function.
- initiate an appropriate supportive management.
- perform the initial evaluation and stabilization of a hemodynamically compromised patient with PH.
• use the Fick principle to calculate cardiac output, shunts and resistance while performing a cardiac catheterisation.
• to understand the indications and appropriate timing of referral to a dedicated specialist in paediatric or adult PH for advanced care.
• recognize deterioration and initiate escalation of treatment (e.g. escalate therapy, refer to specialist service or for transplantation).

Attitudes:
• Ability to communicate sensitively and with compassion.
• Ability to break bad news.
• Recognition of importance of multidisciplinary team (e.g. nurses, psychology) in care for patients with PH.

3.10 Heart Failure and transplantation

General paediatric cardiology training should acquire knowledge and experience on diagnosis of patients with heart failure including a basic introduction to the care of patients with heart failure and post-heart transplants. The basic level is recommended for all paediatric cardiology trainees and should be available at all centres / networks with a training program in paediatric cardiology ³.

Knowledge on heart failure:
• Recognition of the signs and symptoms of heart failure in children, ability to make a differential diagnosis and initiate treatment.
• Understand the pathophysiology and aetiologies (structural and non-structural) of heart failure including atrial pathologies and ventricular-ventricular interactions.
• Familiarity with a variety of diagnostic tools to establish an accurate diagnosis such as non-invasive imaging (echocardiogram and CMR, genetic evaluation, metabolic assessment, endomyocardial biopsy and cardiac catheterisation.
• Assessment, interpretation and value of biomarkers in the acute and chronic phase of heart failure.
• Evaluation and interpretation of the results of arrhythmia testing, exercise testing, biomarker levels, non-invasive imaging, and cardiac catheterisation to plan the appropriate treatment.
• Understanding the principles of medical management of heart failure (acute, chronic and decompensated).
• Familiarity with diuretics, anti-arrhythmic, inotropic and lusitropic agents, anti-coagulation, angiotensin-converting enzyme inhibitors, beta-blockers and age dependent variations in dosing.

• Understanding of the place of additional therapies in the heart failure management including interventional, such as creation of an inter-atrial communication in patients supported by extracorporeal membrane oxygenation, and electrophysiological, such as cardiac resynchronisation therapy and arrhythmia management.

• Application of mechanical circulatory support such as extracorporeal membrane oxygenator support, ventricular assist device support and transplantation in the treatment of end-stage heart failure. Individualized surgical and hybrid strategies should be known for sufficient discussions with surgical colleagues.

Knowledge on cardiac transplantation and mechanical support:

• Indications and contraindications for mechanical circulatory support and heart transplantation.

• Assessment of donor suitability including matching criteria, importance of human leucocyte antibodies and blood group status.

• Outcomes of heart transplantation, including mortality and major morbidities.

• Physiology of the denervated, transplanted heart.

• Complications associated with heart transplantation such as an acute and chronic rejection, coronary allograft vasculopathy and those associated with immunosuppression such as renal dysfunction, infection and post-transplant lymphoproliferative disease.

• Basics of immunology and management of immunosuppressive treatment.

• Common adverse events and drug interactions associated with immunosuppressive medications.

• Blood group (ABO) mismatch transplantation and complications.

• Human leucocyte antibody mismatch transplantations and complications.

• Heart transplant rejection recognition, diagnostic tools and treatment.

• Understanding of mechanical circulatory support in the heart failure patient pathway such as the use of extracorporeal membrane oxygenation and ventricular assist devices as a bridge to transplantation and potentially as a bridge to recovery or as destination therapy in selected groups.

• Familiarity with research areas and methodology relating to advanced heart failure management including epidemiology, novel pharmacological treatments and clinical trials of
novel therapies including stem cell and regenerative strategies.

**Skills:**

The ability to:

- detect warning signs, symptoms, clinical signs of heart failure and interpretation of biomarkers.
- select and use diagnostic techniques to differentiate the underlying causes and precipitating factors of heart failure and to evaluate cardiac function and pulmonary pressures.
- do echocardiographic assessment of heart failure including presence of important CHD, assessment of afterload and ventricular function.
- manage acute and chronic heart failure medically and recognize deterioration and know how to escalate treatment (refer to specialist service or for transplantation).
- educate patients and their relatives about self-care management and the importance of adherence to therapy.

**Attitudes:**

- Ability to communicate sensitively and with compassion.
- Ability to break bad news.
- Recognition of importance of multidisciplinary team (e.g. nurses, psychology) in care for children with end-stage heart failure.

### 3.11 Levels of multidisciplinary family-centred psychosocial care

General, non-disease specific psychosocial interventions intend to decrease negative risk factors and strengthen protective factors in a family. Psychosocial care can be provided at three levels: the individual patient, the parents and the family.

The trainee is expected to be familiar with the basic principles of counselling. Additionally, the trainee is expected to be familiar with the normal development of a child from infant to young adult and the impact which this has on psychosocial care and communication with the patient and family. The influence hereof on the transition of the patient from paediatric to adult congenital cardiology should be respected.
Knowledge:

- Normal development of a child from infant to adult and factors that can interfere with this process.
- Possible psychosocial issues occurring during the lifespan for patients with CHD and their families.
- Psychosocial considerations of the teenage patients during transition and adequate communication style with this patient group.
- Effective communication strategies for an initial approach to psychosocial distress and effective referral to an adequate specialist available.
- Approach to quality of life and methods to assess patients and families quality of life.
- Different therapeutic strategies for psychotherapeutic treatment:
  - Psychosocial counselling and initiation of psychotherapeutic treatment at the level of the individual child / adult with chronic illness focusing on:
    o learning how to cope with physical limitations associated with the chronic condition.
    o learning to cope with negative emotions related with disease or medical procedures (anxiety, anger, sadness, despair, posttraumatic stress, hopelessness / or helplessness).
    o leaning to cope with a loss of control over one’s own body and life.
  - Counselling of parents and initiation of psychotherapeutic treatment focusing on:
    o emotional issues (such as posttraumatic stress and fostering parenthood and parenting the CHD child).
    o providing support to parents regarding their social issues (such as arranging parental leave for cardiac surgery of the child, unemployment, financial problems).
  - Counselling of families and initiation of psychotherapeutic treatment focusing on:
    o aims to gain insight in the inter-relationships within the family.
    o the impact of the chronic illness on each of the family members and the effect of stress on mutual relationships.
    o reducing the negative interactions and teach adequate problem solving and coping strategies.
Skills:

- Be familiar with different styles of communication techniques.
- Recognize the multiple needs of the patient and family and be aware of the limitations of basic counselling and the need of professional support.
- Be able to organise a multidisciplinary approach with psychologists, social workers and play therapists.
- Be able to consider the importance of adequate transition and transfer of patients to the adult clinic.
- Initiate the referral to local and international non-profit associations of patients and their families (such as the European Congenital Heart Disease Organisation, ECHDO) of patients and families when social issues are present.

Attitudes:

- Allow the patients and family members to express their anxiety and concerns when a CHD is diagnosed or when there is a change in the physical state of the patient.
- Allow the patients and family members to express their anxiety and concerns when undergoing interventional or surgical procedures.
- Be aware that psychosocial care is most effective when it is organized in a multidisciplinary setting (collaboration with specialists as psychologists, social workers, nurse specialist etc.).
- Be aware that communication shifts from “primarily with the parents” to “primarily with the patient” when the child grows older.
- Be aware that transfer to the adult clinic should be planned and prepared timely in order to prevent a care gap and potential loss to follow-up.
- Be aware that CHD can have a major impact on career and family planning and that these topics should already be addressed in adolescence.

3.12 Sports Cardiology, physical activity and prevention

The trainee should acquire experience in the assessment and treatment of heart disease risk factors in children and communicate strategies that help patients and families to follow a heart-healthy lifestyle. For patients with CHD, it is important to understand how exercise prescriptions can benefit them and to appropriately detect contraindications to exercise/competition.
Knowledge on prevention:

- Most common cardiovascular risk factors in childhood and adolescence, including the field of "foetal programming" of cardiovascular diseases.
- Cardiovascular risk factors specified for CHD patients, sedentary lifestyle, obesity, diabetes, arterial hypertension and arterial stiffness, dyslipidaemia, survival after oncological treatment, Kawasaki disease and rheumatic diseases.
- The possibilities and limitations of genetic testing in the context of prevention and cardiovascular disease (e.g. predictive diagnostics, reverse cascade screening for familial hypercholesterolemia).
- Effects of physical activity, nutrition, education and psychological risk factors on quality of life, exercise capacity and cardiovascular risk.
- Gender related reference values of body mass index (BMI), blood pressure, lipid status and treatment of elevated values.
- Assessment of vascular risk status using tools to measure e.g. vascular stiffness, distensibility and intima media thickness.
- Prevention of sudden cardiac death in children (most common congenital arrhythmia syndromes).

Knowledge on sports cardiology for healthy young athletes:

- Exercise and sports physiology including benefits of exercise training.
- Pre-participation screening in young athletes stated in the APEC recommendations 19.
- Risk factors for mechanisms of sudden death during and after exercise.
- ECG evaluation and specific ECG findings in athletes: recognizing changes suggestive of primary electrical disease or cardiomyopathy (international criteria) 20, 21.
- Specific ECG criteria and findings in the paediatric athlete.
- Echocardiographic findings in athletes’ hearts including maturational changes of cardiac morphology and function in childhood.
- Spiroergometry (treadmill or bicycle ergometer) principles of performance, interpretation and limitations in childhood.
- Principles in stress imaging in athletes and CHD patients (stress MRI, stress echo).
- Basics in nutritional aspects and drug side effects in athletes.
- Ethical and legal basis of sport examinations (country specific).
Knowledge on sports cardiology for young athletes with congenital heart defect:

- Types of exercises and risks in CHD patients depending on their clinical situation and underlying disease (Bethesda criteria 22).
- Recommendations on physical activity in CHD patients 23.
- Specific issues of patients with electronic devices, cardiomyopathies, ion canal diseases and/or an increased risk of acute cardiac events.
- Evaluation of exercise capacity and causes of exercise intolerance.
- Emergency care for patients during sport competitions.
- Basics of cardiac rehabilitation.
- Counselling of patients with CHD in sports issues.

Skills:
The ability to:

- perform an individual cardiovascular risk assessment using appropriate information from history including laboratory tests and clinical data in healthy children and CHD patients.
- perform a cardiovascular screening evaluation pre-participation in athletic activities in children and adolescents to prevent sudden death.
- perform a physical examination and evaluate physical activity in patients with CHD (and special consideration on disorders going along with cardiovascular risks: obesity, athletes, anorexia, hypertension, Marfan syndrome) and give adequate recommendations for participation in leisure time or competitive sports.
- perform and interpret a cardiopulmonary exercise test.
- recognize pathological cardiovascular changes and differentiate them from the “athlete’s heart”.
- prescribe exercise-based rehabilitation programs and other lifestyle interventions in collaboration with other specialist, according to the CHD patient’s condition.

Attitudes:

- Recognition of the role of an active lifestyle, exercise and sport in the promotion of health and in the prevention of cardiovascular diseases.
- Recognition of the importance of patient and family education and the role of other professionals including nurse specialists, ergophysiologists, psychologists, dieticians and paediatricians in cardiac rehabilitation.
• Recognition and advocating of medical guidance to promote safe training and a healthy
development of the elite paediatric athlete.

3.13 Congenital Cardiovascular Surgery
The trainee should be involved in the collaboration with the cardiac surgeon concerning pre-operative
diagnosis and decision making and acquire the following knowledge:

Knowledge:
• Essential pre-operative information required to refer patients with CHD for cardiac surgery.
• Main surgical indications for large majority of CHD.
• Main surgical techniques for large majority of CHD.
• Be familiar with Risk Stratification and outcome analysis for surgical results.
• Typical complications in the short- and long-term follow-up after cardiovascular surgery.
• Different biological and artificial material used in congenital cardiovascular surgery as types
  of patches, valved and non-valved conduits and grafts, mechanical heart valves and vascular
  prosthesis.
• General theoretical understanding of the cardiopulmonary bypass circuit and anaesthesia
during congenital heart surgery.
• In depths theoretical understanding of surgical procedures.

Skills:
The ability to:
• be able to discuss surgical indications and types of procedures according to the patient’s
  clinical status and imaging records.
• interpret the surgical operation report.
• be able to assess anatomical and pathophysiological results of surgical repair / palliation in
  the early and late outcomes after surgery.
• judge the longer-term consequences and requirements of the postoperative situation.

Attitudes:
• Establish a close collaboration with the surgeons spanning from pre- to post-operative
  management.
4. CERTIFICATION OF COMPLETION OF TRAINING

4.1 Training logbook
The logbook is a tool for the trainee and trainer to keep track of the progress of the trainee. It is the responsibility of the trainee to record all relevant activities. In countries where national guidelines exist the trainee might maintain a national equivalent to the AEPC logbook. The logbook should be countersigned by the trainer confirming that the trainee has satisfactorily achieved the requirements stated according to these recommendations. It is the responsibility of the trainer to audit and certify the activities. The trainee should also keep copies of certificates of attendance of AEPC recommended and approved supplementing courses and add those to the logbook.

4.2 Annual appraisal and assessment
The trainer and/or the head of the department of each institute providing the complete training programme or part of it should carry out appraisals and assessments to evaluate (annually) the progresses of the trainee.

4.3 Final assessment
Ideally, the training should be completed by a final assessment. This could be by means of an exit examination or by continuous assessment of competencies during training. The assessment or examination should combine written, oral and practical components.

5. AEPC EXAMINATION
The AEPC is in the process of developing an AEPC certification/ diploma in paediatric and congenital cardiology.

6. LOGBOOK AND ADDITIONAL INFORMATION
Criteria to get the diploma are based on the statement of the supervising trainer and the individual performance of the trainee. The major part is the presentation of the logbook stating the respective, individual performance.
The following documents are necessary:

- Proof of training written by the supervising trainer.
- Logbook documenting completion of required procedures.
- Involvement in one research project.
- Certificate of attendance of two national or international meetings in paediatric cardiology / congenital heart surgery.
- One published article and / or presentation on the above-mentioned congresses.

### 6.1 Logbook of procedures

**Purpose:**
To ensure that the trainee has adequate exposure to a range of clinical procedures and techniques in preparation for physician practice.

**Requirement:**
A logbook showing details over the course of training and kept updated regularly throughout the training is essential. The trainee must maintain all performed clinical procedures including the information about the level of supervision in the logbook. Supervisors are required to confirm in their reports that the logbook is a true and accurate record of the trainee’s experience and that all training requirements have been fulfilled.

### 6.2 Procedures / activity

- **Ambulatory care:**
  - Manage patients in an ambulatory care (outpatient) setting under supervision - minimum number: 200 patients.

- **Balloon atrial septostomy:**
  - Perform balloon atrial septostomy cases under supervision and demonstrate competency as an independent operator - minimum number: 5 cases.

- **Cardiac catheterisation:**
  - Perform and report cardiac catheterisation and haemodynamics - minimum number: 70 cases.
  - Perform and report cardiac catheterisation as primary operator - minimum number: 20 cases, included in total requirement of 70 cases.

- **Direct current cardioversion:**
- Perform direct current cardioversion - minimum number: 5 cases.

- **Echocardiograms:**
  - Fetal echocardiograms (observation and associated counselling) - minimum number: 20 studies.
  - Transoesophageal echocardiograms - minimum number: 50 studies, 25 studies as a primary operator (all studies should be reviewed and have finalized consultant reports).
  - Transthoracic echocardiograms - minimum number: 500 cases, 300 under supervision of a paediatric echocardiographer / cardiologist and at least 400 on patients with cardiac pathology (all studies should be reviewed and have finalised consultant reports).

- **Electrocardiograms:**
  - Interpret and report electrocardiograms on both inpatients and outpatients - minimum number: 150 cases.

- **Electrophysiology:**
  - Participate in clinical decision-making for electrophysiology study / ablation procedure, including observation of procedures and interpretation of reports - minimum number: 10 cases.

- **Exercise tests:**
  - Supervise and report exercise tests - minimum number: 50 cases.

- **Holter monitor:**
  - Supervise and report Holter monitor - minimum number: 50 cases.

- **Imaging:**
  - Interpret chest x-rays - minimum number 100 cases.
  - Interpret results of CMR, thoracic CT and radionuclide imaging - minimum number: 10 cases (in total).

- **Pacemaker:**
  - Observe pacemaker implantation - minimum number: 5 cases.
  - Participate in testing permanent pacemaker function - minimum number: 20 cases.
  - Perform pacemaker testing - minimum number: 20 cases.

- **Pericardial aspiration:**
  - Perform pericardial aspiration under supervision and demonstrate competency as an independent operator - minimum number: 3 cases.
7. REFERENCES


15. Walsh F. Traumatic loss and major disasters: Strengthening family and community resilience.


Table 1. Most common congenital and acquired cardiac diseases from foetus to adult

Non-cyanotic cardiac defects:
- Atrial septal defect and abnormal pulmonary venous return
- Ventricular septal defect
- Atrioventricular septal defect
- Patent arterial duct
- Aorto-pulmonary window
- Pulmonary stenosis (valvular, infundibular, supravalvular and peripheral)
- Ebstein anomaly of the tricuspid valve
- Double chambered right ventricle
- Aortic stenosis (valvular, infundibular and supravalvular)
- Coarctation of the aorta and interrupted aortic arch
- Mitral valve disease (prolapse, cleft, parachute mitral valve, double orifice mitral valve)
- Hypoplastic left heart syndrome (HLHS)
- Double discordance (L-TGA)
- Coronary artery fistula

Cyanotic cardiac defects:
- Pulmonary atresia with intact ventricular septum and with ventricular septal defect
- Critical pulmonary stenosis
- Tetralogy of Fallot
- Transposition of the great arteries (TGA)
- Double outlet right ventricle
- Truncus arteriosus
- Total anomalous pulmonary venous connection
- Univentricular atrioventricular connection
- Complex congenital heart disease associated with abnormalities of cardiac position and situs

Critical CHD requiring emergency postnatal treatment:
(neonatal and perinatal management based on prenatal diagnosis)
- TGA with restrictive foramen ovale
- HLHS with restrictive / closed foramen ovale
- Mitral valve dysplasia syndrome
- Ebstein anomaly of the tricuspid valve or tricuspid valve dysplasia with “circular shunt”
- Restrictive total anomalous pulmonary venous connection (very difficult for prenatal diagnosis)

Critical ductal dependent CHD:
(stabilisation of circulation met postnatal start of prostaglandin)
- Left heart lesions: aortic stenosis, HLHS
- Systemic ductal dependent lesions in complex CHD (e.g. tricuspid atresia with TGA, double inlet left ventricle with hypoplastic aortic arch)
- TGA
- Double outlet right ventricle – transposition type (Taussig–Bing anomaly)
- Critical pulmonary stenosis and pulmonary atresia with intact ventricular septum
- Ductal dependent pulmonary circulation (defects with fetal left to right or bidirectional shunt across the arterial duct)
- Coarctation of the aorta / interrupted aortic arch

Cardiovascular symptoms and disorders:
- Failure to thrive
- Dyspnoea
- Palpitations
- Oedema
- Cyanosis
- Chest pain
- (Pre)-Syncope
- Pulmonary hypertension
- Inflammatory cardiovascular disease (rheumatic heart disease, Kawasaki disease)
- Cardiomyopathies
- Endocarditis
- Myocarditis
- Cardiac anomalies associated with genetic disorders and syndromes
- Acquired valvular diseases
- Pericardial diseases
- Cardiac tumors

**Cardiac arrhythmias:**
- Supraventricular arrhythmias
- Foetal supraventricular tachycardia / atrial flutter (transplacental treatment)
- Ventricular arrhythmias
- Complete congenital atrio-ventricular block with normal cardiac anatomy
- Complete atrio-ventricular block with CHD (left atrial isomerism, L-TGA)
- Foetal sinus bradycardia (risk for long QT syndrome)

**Foetal functional cardiac disorders:**
- Premature restriction/closure of the arterial duct – risk of postnatal pulmonary hypertension
- Right ventricular outflow tract obstruction due to twin to twin transfusion syndrome
- Hypertrophic cardiomyopathy due to twin to twin transfusion syndrome or maternal diabetes
- Premature closure of the foramen ovale, commonly secondary to arrhythmia (atrial ectopic tachycardia, junctional ectopic tachycardia)

CHD = Congenital Heart Disease
Table 2. Underlying principles of training

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<tr>
<th>Teaching &amp; Learning Methods</th>
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<tbody>
<tr>
<td>• Learning with peers</td>
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<tr>
<td>• Work-based experiential learning</td>
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<tr>
<td>• Paediatric cardiology on call</td>
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<tr>
<td>• Consultant-led ward rounds</td>
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<tr>
<td>• Multidisciplinary team meetings</td>
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<tr>
<td>• Formal postgraduate teaching</td>
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<td>• Independent self-directed learning</td>
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<tr>
<th>Assessment:</th>
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<tr>
<td>• Work place-based</td>
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<tr>
<td>• Clinical assessment, case discussion, patient surveys, supervision, feedback</td>
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<tr>
<td>• Record of assessment, progress logbook, portfolio of educational activities</td>
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<tr>
<td>• Multisource feedback</td>
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